2 Database and Investigation Summaries

Data have been collected from the Lower Fox River and Green Bay during numerous sampling events over a ten-year period. The *Data Management Summary Report* (DM Report) (EcoChem, 2000) presents the 35 studies which comprised the original Fox River Database (FRDB). EcoChem also completed an evaluation of five additional data sets from 2000 and 2001 which were added to the final FRDB. The evaluation is presented in the *Addendum to the Data Management Summary Report* (DMR Addendum) prepared by EcoChem (EcoChem, 2002). The DM Report and DMR Addendum are included as Appendix A. This section briefly summarizes the data contained within the FRDB and presents some of the larger studies that contributed to the database. The general conclusion of the DM Report is that almost all of the data gathered during previous investigations and included in the FRDB is of good quality.

After the draft RI and DM Reports were released in February 1999, the EPA authorized a peer review of these documents by Roy F. Weston, Inc. (Weston). The general conclusions of the peer review included the following:

1) The quantity and quality of data are good enough to support the need for cleanup action;

2) The data are adequate to determine the distribution of contaminants within the system and direct where cleanup actions should focus; and

3) The data are adequate to support identification and selection of possible remedy technologies (Weston, 1999).

Data included in the FRDB were collected during localized and regional studies pertaining to water and sediment quality, biological count and diversity studies, biological tissue sampling efforts, stream flow, and anthropogenic impacts on river quality and bio-diversity in the watershed. The WDNR, USFWS, EPA, academic researchers, and other public and private groups completed these studies. This RI utilizes the sediment and water quality data which meet data quality objectives established for the project in the *June 1998 Work Plan* (RETEC, 1998a) and the *Quality Assurance Project Plan* (QAPP) (RETEC, 1998b). The main sediment studies from which the FRDB has been derived are summarized below.

This RI focuses mainly on sediment and water sampling results within the Lower Fox River and Green Bay. Although there is a significant amount of fish/bird

tissue and other biological sampling data in the FRDB, these data are only summarized herein. The detailed analysis of ecological (biological) sampling and trends are presented in the RA and the *Time Trends Analysis*, included as Appendix B. The RI only introduces the studies that collected these data and provides a brief summary of the PCB concentrations in the ecological samples.

2.1 Data Quality Evaluation

The studies composing the FRDB are listed on Table 2-1, along with information pertaining to the type and quantity of data collected. All the data included in the FRDB have been subject to a validation process to evaluate the RI/FS/RA database quality. Additional details regarding the data quality review are described in the DM Report (EcoChem, 2000). The DM Report classifies data sets used for the FRDB as follows:

- **Useable Data** - data have been thoroughly assessed through review of the analytical data itself and associated quality assurance/quality control (QA/QC) documents. The data are of known and verifiable quality.

- **Supporting Data** - supporting data have not been subjected to as rigorous an assessment as the useable data. As such, the precise data quality is not known. This is due to insufficient or incomplete QA/QC information available at the present time. In these cases, QA/QC information may or may not exist. The collection and assessment of this information might render the data fully useable. Until a full data validation is conducted, these data should be used for supporting purposes only.

- **Indeterminate Data** - status of a data set is described as indeterminate if: it is unknown whether the data set has been validated, and/or, QC data to support validation is not available.

Both the "Useable" and "Supporting" data sets are used in this RI. EcoChem has provided these data for use in the RI and the resulting analysis of the data presented in this document (particularly Section 5) uses the data as received, unless otherwise noted.

Although all but one of the data sets listed in Table 2-1 were classified as either usable or supporting, individual data points were rejected due to QA/QC failure. These rejected data points have not been used in the RI/FS/RA. The Ankley and Call data is the only indeterminate set in the FRDB.

2.2 Sediment Investigations Included in the FRDB

2.2.1 1989-1990 Fox River Mass Balance Study Data and 1989-1990 Green Bay Mass Balance Study Data

In 1989-90, EPA and WDNR conducted sediment and water sampling activities in the Lower Fox River and Green Bay as part of the Green Bay Mass Balance Study (GBMBS). The GBMBS was designed to identify the sources, transport paths, and fate of PCBs in the Lower Fox River and Green Bay. Important components of this effort were two PCB transport models that evaluated and modeled the transport pathways and fate of PCBs in the Lower Fox River and Green Bay. The Upper Fox River (UFR) Mass Balance model evaluated the transport and fate of PCBs between LLBdM and the De Pere dam. Similarly, the Lower Fox River (LFR) Mass Balance model evaluated the transport and fate of PCBs from the De Pere dam into Green Bay. A discussion of these modeling efforts is included in Section 6.

The GBMBS evaluated PCBs, lead, cadmium and dieldrin in the De Pere to Green Bay Reach and Green Bay while efforts upstream of the De Pere dam were limited to evaluating and modeling PCBs (including specific PCB congeners). The GBMBS objectives included:

- Mapping soft sediment deposits and quantifying the current PCB mass in the bottom sediments.

- Collecting data over a one-year period for use in calculating PCB fluxes into and out of the river system, including inputs from permitted wastewater dischargers, landfills, groundwater, urban runoff, Lake Winnebago, atmospheric input and resuspension of in-place polluted sediments. Outputs included transport over De Pere dam and volatilization.

- Increasing the understanding of the physical, chemical, and biological processes that affect the above fluxes.

- Developing a model describing the above processes, and calibrating and validating the model using a comprehensive set of physical and chemical data.

- Conducting predictive simulations to assist in the assessment of specific management scenarios and in selection of specific remediation strategies.

In the Lower Fox River, monitoring and quality assurance programs were developed during 1986 and 1987, and sampling began in 1988. Field work occurred from April 1989 to April 1990 along with data set management and model development. From 1990 to 1992, samples were analyzed, data interpreted, and modeling conducted. As part of this effort, areas with accumulated sediments were identified through poling efforts. This effort identified the sediment deposits outlined on Figures 1-3 through 1-5 and the almost continuous presence of sediment below the De Pere dam (Figure 1-6). Based on the presence of soft sediments within a given area/location, a sample was collected for laboratory analysis of PCBs and other parameters.

A similar time-frame was followed for Green Bay, except that sediment sampling in Green Bay occurred between 1987 and 1990 (Manchester-Neesvig, *et al.*, 1996). Also, due to the areal expanse of Green Bay, 169 sediment sampling stations were established using a 5 km x 5 km (3.1 mi x 3.1 mi) grid. The presence or absence of soft river/bay sediments was established using a Ponar Grab sampler. Based on the presence of soft sediments, a core sample was collected for analysis of PCBs. Although 169 sampling stations were established (based in the 5 km grid), a grab or core sample was collected from only 123 stations and of these, cores from only 64 locations were analyzed for PCBs (Manchester-Neesvig, *et al.*, 1996).

Sediment cores collected from both the Lower Fox River and Green Bay were sliced into as many as 28 individual samples. These samples were submitted for laboratory analysis and provided data on the PCB concentrations throughout the sediment profile. In many instances, these sediment slices represented 1 or 2 cm intervals in the profile and the thickness was based on the total length of the recovered sediment core.

The initial 1989-90 Lower Fox River sediment sampling results indicated that approximately 3,900 kg (8,600 pounds) of PCBs are distributed in about 2,100,000 cubic meters (m^3) or 2,745,000 cubic yards (yd^3) of sediment between Lake Winnebago and the De Pere dam. Of this amount, approximately 50 percent of the PCB mass (1,950 kg [4,300 pounds]) was located in LLBdM (WDNR, 1995). Based on the presence of a continuous layer of sediment extending from the De Pere dam to the mouth of the river, the WDNR collected additional samples downstream of the De Pere dam in 1995. Information pertaining to this sampling event is presented in Section 2.2.6.

In Green Bay, the PCB data were evaluated to provide an estimate of the PCB mass and volume of contaminated sediments. Based on the PCB results,

Manchester-Neesvig, *et al.*, (1996) estimated that approximately 8,500 kg (18,740 pounds) of PCB are present in the bay. The majority of the PCB within the bay was estimated to be located along the east shore, from the mouth of the river to approximately Little Sturgeon Bay. Manchester-Neesvig, *et al.,* (1996) also estimated that in order to even remove 20 percent (about 1,700 kg) of the PCB in the bay would require dredging approximately 14 million m^3 (18.3 million yd^3). These results reflect the large diffuse nature of PCB contamination within Green Bay.

Other results indicate that significant factors affecting PCB transport appear to be the concentration and composition of suspended particulate matter, the initial PCB concentration in sediments, and river flow. These factors interact in complex ways and the deposition and resuspension of particulate matter largely controls PCB transport. Under typical flow conditions, the average PCB concentrations in water samples ranges from 4 nanograms per liter (ng/L or parts per trillion) flowing out of Lake Winnebago to an average of 47 ng/L in the De Pere to Green Bay Reach. PCBs are suspended and/or dissolved in the water column as flow moves downstream towards Green Bay. During summer, water sample PCB concentrations range between 50 and 90 ng/L at the De Pere dam. However, in winter, the PCB concentrations are approximately 10 percent of the summer values, indicating a strong seasonal variation (Fitzgerald and Steuer, 1996). In addition, when river flow is at its highest due to storm events or spring runoff, the PCB concentrations in water may exceed 100 ng/L. Based on the seasonal variations in PCB concentrations, it is estimated that more than 60 percent of the PCBs transported over the De Pere dam occurs during 20 percent of the year, when discharge is at its greatest (Fitzgerald and Steuer, 1996).

Based on the seasonal variation in water column PCB concentrations, water samples were collected and analyzed for concurrent concentrations of chlorophyll a, the most common algal pigment. Results of these samples indicate that there may be a link between algal productivity and water column PCB concentrations (Fitzgerald and Steuer, 1996). This potential link may suggest that algal production, predation, sinking, and other dynamics may be an important process facilitating the transport and ultimate fate of PCBs in the river. Additionally, bioaccumulation of PCBs by algae may provide a pathway for PCBs into the food chain and other organisms.

The GBMBS modeling efforts identified the location and magnitude of PCB contaminated sediment, evaluated areas contributing to transport and fish consumption advisories, and was used to predict future PCB concentration changes, with and without human intervention, over 25 years (Velleux and

Endicott, 1994; WDNR, 1995). This effort indicated that river sediment is the most significant continued source of PCBs in the river.

2.2.2 1994 Woodward-Clyde Deposit A Sediment Data

WDNR contracted with Woodward-Clyde Consultants (WCC-formerly EWI Engineering Associates) to perform an RI/FS for Deposit A. Based on the results of this effort, WDNR selected dry sediment removal as the remedial alternative for addressing PCB contaminated sediments from Deposit A (Figure 1-3). Dry sediment remediation includes enclosing Deposit A with a temporary cofferdam followed by the dewatering, treatment, and landfilling of the PCB contaminated sediments.

WCC collected additional sediment samples from 14 locations previously containing PCB levels above 50 ppm. Fifteen geotechnical soil borings were completed to further classify sediment and soil in the areas to be remediated, to measure index and engineering properties, to characterize the sediment and underlying soil interface, and to evaluate the presence or absence of more permeable zones within the underlying soil. Results of the geotechnical evaluation indicated that the soil underlying the sediments were softer than indicated by previous data; however, WCC concluded that the cofferdam could be constructed using sheetpile, earth berm, or portable dam alternatives (WCC, 1994 and 1996).

Several bench scale tests were conducted to evaluate the effort involved with preparing the impacted sediments for disposal. The objectives of the sediment handling operations included reducing the sediment weight and volume through drainage and evaporation and to dry and/or solidify the sediments sufficiently for off-site transportation, handling, and landfill disposal. The test results indicated the sediments could be dried relatively quickly, especially when mixed and heated; also, the sediments could be effectively solidified with a bentonite and cement mix at the existing water content.

2.2.3 1992/93 BBL Deposit A Sediment Data

On behalf of the P.H. Glatfelter Company, Blasland, Bouck, & Lee (BBL) performed an RI/FS for LLBdM Sediment Deposit A in 1992/93 (Figure 1-3). BBL conducted additional sediment sampling in Deposit A as well as a baseline human health and ecological risk assessment which evaluated the risks associated with exposures to surface water, sediment, and fish ingestion. BBL used WDNR fish samples collected through 1992 as the basis for this evaluation.

The main findings of the BBL RI/FS included the following: 1) All locations exhibited decreasing PCB concentration with depth with Aroclor 1242 being the primary PCB detected in sediment; and 2) Ingestion of fish posed the greatest risk for exposure.

2.2.4 1993 Triad Assessment

This sediment study sought to characterize soft sediments in the Lower Fox River using the sediment quality triad approach. Using triad and weight of evidence approaches, WDNR applied sediment quality guidelines (SQGs), human health criteria, and wildlife criteria for the protection of benthic life within the Lower Fox River (WDNR, 1992). These three criteria were used to evaluate the degree of sediment contamination. This approach assessed sediments by determining the presence and degree of anthropogenic contamination (bulk chemistry), by assaying the effects of sediments on normal function (growth, reproduction, survival) of standard test organisms, and by assessing in-situ alterations of the benthic community structure (WDNR, 1996).

In 1992 and 1993, sediments were collected from 10 deposits between Lake Winnebago and Green Bay and the following chemical parameters were analyzed: PCBs; chlorinated pesticides; volatile organic compounds (VOCs); semi-volatile organic compounds (SVOCs), including PAHs and PCP; metals; and ammonia. Additionally, physical characteristics of the sediment were recorded, sediment toxicity was analyzed using acute and chronic bioassays, and macroinvertebrate community structure was examined.

Sediment enrichment factors (SEFs) were calculated by dividing the sediment concentrations in a deposit by a reference sediment concentration to compare chemical composition between deposits. All deposits were found to be chemically enriched by certain constituents and PCBs were the primary constituent that resulted in elevated SEF values. Mercury, total PAHs and ammonia were also found to be enriched in all deposits analyzed. Other enriching contaminants were found in some but not all deposits.

Acute and chronic toxicity testing was also completed. The acute toxicity testing results revealed very low mortality to Ceriodaphnia dubia and Daphnia magna as survival exceeded 90 percent and 70 percent, respectively; Hylella azteca was the most sensitive indicator of acute toxicity with significant mortality rates at five of the ten test sites. The chronic toxicity testing results indicated that both Daphnia magna and Chironomous tentans were adversely affected and exhibited reductions in survival, reproduction, and growth rates (WDNR, 1996).

Macroinvertebrate investigations were inconclusive because of deposit abundance variability, unidentified worm taxa dominant in most deposits, and physical substrate differences. Bioassay tests indicated both acute and chronic toxicity for several deposits throughout the length of the river. The deposits with maximum contaminant concentrations were not always the same as deposits with the maximum toxicity or benthic impact. It was reasoned that this could be due to other factors that can influence toxicity that were not measured, including: dissolved oxygen in the pore water and overlying water; pH levels; substrate variation and/or other confounding factors such as sampling season; specific concentrations of contaminants based on vertical profiles; availability of microfauna for food; nutrient fluxes; and algal growth.

2.2.5 1994 GAS/SAIC Sediment Data

In 1994, WDNR and the Fox River Coalition (individuals representing both public and private sector interests), jointly undertook completion of an investigation of the upper three reaches of the Lower Fox River. Graef, Anhalt, Schloemer & Associates Inc. (GAS) and Science Applications International Corporation (SAIC) were contracted to identify the lateral and vertical extent of PCBs and mercury within bottom sediments at selected deposits upstream of the De Pere dam (GAS and SAIC, 1996). The deposits were selected by WDNR based on a ranking system that included transport, bio-availability and PCB mass as well as other considerations. The deposits studied included: 1) Deposit POG, located on the east side of LLBdM; 2) Deposits D and E, located on the west and north ends of LLBdM; 3) Deposit N, located near the city of Kimberly; and 4) Deposits EE, GG, and HH, located just upstream of the De Pere dam. In addition to identifying the extent and magnitude of PCBs and mercury in sediments, a baseline ecological and human health risk assessment and a preliminary assessment of feasible remedial alternatives were completed.

2.2.6 1995 WDNR Sediment Data

This study was funded and carried out by the WDNR, EPA Great Lakes National Program Office (GLNPO), and the Fox River Coalition. During the 1989-90 sediment sampling activities, a large, continuous sediment layer, which extended from the dam to the mouth of the river, was found in the De Pere to Green Bay Reach. Based on the 1989-90 sediment sampling data, it was estimated that this reach contained between 80 percent and 90 percent of the total PCB mass in the Lower Fox River. Due to the significance of sediments as a continuing source of PCBs, WDNR concluded that sediments downstream of the De Pere dam required further characterization in order to adequately model and predict PCB fate and transport from the river into Green Bay. The primary objectives of the 1995 sampling effort (WDNR, 1998) include the following:

- To further define and quantify the PCB sediment distribution downstream of the De Pere dam to Green Bay

- Estimate the mass and volume of PCB containing sediments and develop maps of PCB distribution in the Lower Fox River

- Provide data to enable further refinement of the PCB transport models for the Lower Fox River

- Provide further basis for making sound management decisions throughout the Lower Fox River and into Green Bay

- Support the Fox River Coalition's effort to prioritize contaminated sediment areas and remediate sites in the Lower Fox River

- Implement a Green Bay Remedial Action Plan recommendation for developing a cleanup strategy for the Lower Fox River sediments

WDNR analyzed hundreds of samples for PCBs, total organic carbon (TOC), moisture content, and particle size (plus QA/QC samples). Sediments containing more than 1,000 microgram per kilogram (μg/kg) (1 ppm) of PCB were detected as deep as 200 cm (78.7 inches) below the river bottom and the PCB concentrations above these locations were not significantly lower. WDNR (1998a) estimated that approximately 26,000 kg (57,320 pounds) of PCB was present in this reach.

2.2.7 1996 FRG/BBL Sediment/Tissue Data

In 1996, BBL performed limited sediment sampling in the same deposits investigated by GAS/SAIC on behalf of the FRG. BBL collected eight sediment samples from deposits POG, N, GG and a reference site. These samples were analyzed for PCBs and TOC.

2.2.8 Sediment Remediation Demonstration Projects Data

Two Sediment Remediation Demonstration (SRD) Projects were conducted between 1998 and 1999 at Deposit N and SMU 56/57 to assess the effectiveness of sediment remediation using dredging techniques in the Lower Fox River.

The Deposit N SRD project, located near the town of Kimberly, was funded and completed through an agreement between the WDNR, EPA GLNPO, and the Fox River Coalition. The Deposit N SRD project was successfully completed to design

specifications and achieved the target goals for the project. Deposit N sediment data is included in five different sets in the FRDB (Table 2-1). These data sets include the 1997 Demonstration Project Data, 1998 Deposit N Pre- and Post-Dredge Data, the Operational Monitoring Data, and the 1998/1999 Remediation Data.

The SMU 56/57 SRD project located downstream of the De Pere dam, was conducted on behalf of the WDNR and the FRG, with funding provided by the FRG. However, because the targeted design depths were not achieved only part of the designated PCB mass was removed. The SMU 56/57 sediment data is included in the 1997 Demonstration Project Data Set in the FRDB (Table 2-1). Dredging equipment will be remobilized to SMU 56/57 during the summer of 2000 to remove the remaining PCB-contaminated material under administrative order between EPA and the Fort James Corporation (EPA, 2000a). Each of these demonstration projects is discussed briefly below and is detailed in the *Sediment Technology Memorandum* located in Appendix B of the FS.

The SRD projects assessed various phases of sediment remediation including dredging, dewatering, and disposal. The objectives of the SRD projects included the following:

- Assess the implementability, feasibility and cost of a full-scale sediment remediation project for other areas of the Lower Fox River

- Remove the bulk of PCB mass from impacted sediment located within two large hot spots of the Lower Fox River for source control

- Conduct a mass balance study of PCB mass transport during dredging activities to help assess dredging effectiveness

- Assess the extent of sediment resuspension during dredging and the downstream transport of PCB material along with the performance of containment systems and monitoring devices

- Collect technical information which will be useful during the final evaluation and selection of remedial alternatives such as: flow velocity, sediment characteristics, bulk density, extent of debris and obstructions, dewatering and treatment characteristics, and dredging costs.

2.2.8.1 Deposit N Demonstration Project

The former Deposit N is located within the city limits of Kimberly and adjacent to the Interlake Papers facility, on the south side of the river (Figure 1-4). Deposit N sediments were evaluated during both the WDNR 1989-90 and GAS/SAIC 1994 sampling efforts. Deposit N was estimated to be about 1.21 hectares (3 acres) in size and have an average PCB sediment concentration of 45 ppm. Water depths at the location were generally 244 cm (8 ft) deep and the average sediment thickness was about 61 cm (2 ft). Deposit N Sediment samples collected by Foth & Van Dyke (F&VD) indicated that total PCB results ranged from 550 to 130,000 μg/kg prior to remediation. F&VD estimated that approximately 142 kg (312 pounds) of PCBs were present in Deposit N (F&VD, 2000).

Remedial Action. Sediment removal was conducted using an 8-inch Moray/Utra hydraulic cutterhead dredge with a swinging ladder configuration, a rotating variable-speed cutter, and an intake/suction line. A special containment system was installed around the deposit to ensure that sediments resuspended during construction would remain within the dredged area and be removed in the cleanup process. The containment system consisted of a 80-mil high density polyethylene (HDPE) curtain anchored to the river bed and buoyed by flotation devices. The curtain acted as a flexible wall effectively preventing suspended sediments from flowing downstream with the current. The chronological summary of site activities at Deposit N is listed below.

Hydraulically dredged material was pumped through double-walled piping to the on-shore treatment system. Sediment slurry was screened to remove gravel and sand (>#200 sieve), conditioned with a polymer to increase the percent solids, then pumped into 200 pounds per square inch (psi) filter presses for compression. The compressed solid material was stockpiled and tested for PCBs, mercury, and percent solids. Water separated during pressing was treated through solid filtration and carbon adsorption prior to discharge back to the Lower Fox River.

Based on PCB concentrations relative to Toxic Substances Control Act (TSCA) standards, dried sediment was transported to either the Winnebago County Landfill (PCB concentration less than 50 ppm) or the Wayne Disposal landfill in Belleview, Michigan (PCB greater than 50 ppm) in 1998. During 1999, all dredged sediments were transported to the Winnebago County Landfill (Fitzpatrick, 2000).

Monitoring. The environmental monitoring program focused primarily on bathymetry surveys, sediment sampling, water quality monitoring during

dredging, and post-verification surface sediment sampling. WDNR collected water samples during remediation activities to evaluate whether significant concentrations of PCBs were released from the sediment into the water column.

The Fox River Remediation Advisory Team (FRRAT) determined that the best method for assessing the effectiveness of dredging was a mass balance approach. The mass balance approach included three essential components: deposit mass balance, river transport, and process mass balance. Twenty surface sediment samples were used to assess residual concentrations and daily surface water samples collected from upstream and downstream transects at two depths were used to determine river transport (along with estimated flow measurements provided by USGS). Chemical analyses of the byproducts of the treatment products were used to determine PCB fate during the dredging process.

Results. Due to the presence of a hard bedrock substrate located beneath the soft sediments, the target goal of the demonstration project was to remove contaminated sediment down to a design depth of 7.5 to 15 cm (3 to 6 in [inches]) above bedrock. Approximately 5,475 m^3 (7,160 yd^3) of sediment and 50.3 kg (112 pounds) of PCBs were removed from Deposit N during 1998/1999 (F&VD, 2000). Overall, 82 percent of the PCB mass was removed from Deposit N and approximately 31 kg (68 pounds) of PCB remained in the sediments that were not accessible to dredging activities (F&VD, 2000).

The PCB mass balance study conducted during dredging activities (FRRAT, 2000), estimated that the resulting press cake material contained 96 percent of the PCBs removed from the deposit and that less than 0.01 percent of PCBs from the slurry concentration was discharged back to the river. The mass balance model did not measure an overall increase in mass of particles transported downstream during dredging (TSS), however, the PCBs transported on the particles did increase (increased net load of 2.2 kg PCB during the active dredging period).

Currently, there are no further plans for additional work at Deposit N. Data collected from Deposit N prior to completion of the SRD has been flagged in the FRDB and only post-remediation data was evaluated as part of the RI/FS and RA. According to WDNR, the remedial activities completed at Deposit N have essentially removed this deposit from the river (Fitzpatrick, 2000).

2.2.8.2 SMU 56/57 Demonstration Project

SMU 56/57 is located within the Green Bay city limits and adjacent to the Fort James Corporation facility, on the west bank of the Lower Fox River (Figure 1-6).

Based on the WDNR 1995 sediment sampling results, SMU 56/57 contained the highest PCB concentrations detected anywhere in the Lower Fox River and Green Bay. An estimated 3,000 kg (6,600 pounds) of PCBs were present within a total sediment volume of approximately 69,800 m^3 (91,300 yd^3) encompassing an area of approximately 3.7 hectares (9.3 acres) (Montgomery Watson, 1998). These sediments were estimated to contain approximately 10 percent of the total PCBs downstream of the De Pere dam, although the volume only represented about 1 percent of the estimated sediment volume downstream of the De Pere dam.

Results of the baseline sediment sampling collected by Montgomery Watson in 1998 indicated that most sediment cores contained PCBs throughout their entire length extending to almost 5 m (16 ft) in some areas. The laboratory results indicated that the highest PCB concentrations were generally located between a depth of 61 to 153 cm (2 to 5 ft) below the sediment surface. Total PCB concentrations ranged as high as 710,000 μg/kg. Approximately one third of the cores reached undetectable PCB concentrations at the deepest interval tested. Similarly, mercury concentrations increased with depth across the site. Concentrations averaged approximately 1 mg/kg in the 0 to 10 cm (0 to 4 in) interval and increased to approximately 7 mg/kg in the 274 to 305 cm (9 to 10 ft) interval.

Remedial Action. The SMU 56/57 dredging demonstration project began on September 1, 1999, with the objective of removing about 61,160 m^3 (80,000 yd^3) of impacted sediment. The target area was isolated from the rest of the river through the installation of an anchored silt curtain. Material was extracted from the riverbed using a hydraulic cutterhead and horizontal auger dredges and dewatered on-shore. Sediment was dewatered through equalization basins and filter presses then transported to an engineered landfill cell owned by the Fort James Corporation for disposal. Process water was treated with polymer, run through sand/carbon filters and discharged back to the river. The chronological summary of site activities at SMU 56/57 is provided below.

Equipment difficulties and the presence of large debris significantly slowed the pilot test progress. During early stages of the project, coal ships docking at the Fort James facility disturbed the silt curtain, ripping it from its moorings on at least one occasion. Also, the liner of one of the two settling ponds was damaged during October 1999 requiring use of that pond to be discontinued until the liner could be repaired. The initial goal of removing 61,160 m^3 (80,000 yd^3) was reduced by nearly half, due to increased costs caused by these and other delays. Dredging was suspended on December 15, 1999, due to ice on river and icing of the wastewater treatment system.

Monitoring. The environmental monitoring program focused primarily on bathymetry surveys, sediment chemistry sampling, and surface water quality monitoring. Post-dredging sampling activities were initiated on December 20, 1999 and continued through early January 2000. An acoustical bathymetry survey completed after suspension of the dredging activities indicated that approximately 22,940 to 23,700 m^3 (30,000 to 31,000 yd^3) of sediment were removed from the target area. A PCB mass balance study was conducted during dredging to compute the mass of PCBs discharged to the river during dredging. Samples were collected from the dredge slurry, dewatered solids, supernatant, and process water effluent.

Results. The target goal of the project was to dredge to a design elevation of 565 feet, mean sea level. Dredging to this design elevation was expected to remove sediments with PCB concentrations greater than 1 ppm. However, the target elevation was not achieved in any of the subunits within the dredge prism. Due to the difficulties encountered during dredging and the on-set of winter, the expected elevation was raised 2 to 3 feet in most areas. A final "cleanup pass" initially intended for all areas was only completed in four of the 59 subareas (WDNR, 2000a). In these areas, the final PCB concentrations in the newly exposed surface sediments showed a general decline compared with pre-dredging concentrations, and in some locations the final PCB concentrations were as low as 0.25 ppm. However, in other areas where no “final pass” was completed down to the targeted sediment elevations, the final PCB concentrations were higher (32 to 280 ppm) than baseline surface concentrations (2 to 5 ppm) (Montgomery Watson, 2000). In these areas, the final sediment elevations achieved were 30 to 230 cm (1 ft to 7.5 ft) above the targeted elevations.

Under an EPA Administrative Order by Consent (AOC No. V-W-00-C-596), the Fort James Corporation continued sediment remediation activities at SMU 56/57 during the summer, 2000. The dredging activities conducted in two phases:

- Phase 1 - removal of contaminated sediment from subunits that were previously disturbed (dredged) during the SRD project to SRD target elevations (estimated 15,290 m^3 [20,000 yd^3]).

- Phase 2 - removal of additional sediment from different subunits that were not disturbed during the SRD project.

The total in-situ dredge volume of the two phases will not exceed 38,225 m^3 (50,000 yd^3), given the need to preserve stable side slopes, not exceed the capacity of the landfill, and avoid leaving residual elevated PCB concentrations. Surficial sediments will be tested to determine if cleanup objectives (1 ppm PCBs) have

been met. However, dredging activities will cease after the removal of 38,225 m^3 (50,000 yd^3) regardless of residual PCB concentrations.

Conclusions. Conclusions drawn from both SRD dredging projects indicate the following:

- Pre-dredging data provided sufficient resolution to define the lateral and vertical extent of contamination;
- Contaminated sediment can be removed within the river without increasing surface concentrations; and
- Partial cleanup left significantly higher PCB concentration in some surface sediments where the target elevation was not achieved.

The estimated PCB mass and sediment volume removed during the SMU 56/57 SRD project have been subtracted from the mass and volume estimates for the De Pere to Green Bay Reach in this RI (Section 5.4.2.6).

2.2.9 1998 FRG/Exponent Data and 1998 FRG/BBL Sediment/Tissue Data

During 1998, the FRG hired both BBL and Exponent Environmental Group (Exponent) to evaluate various aspects of the Lower Fox River and Green Bay. BBL collected at least 363 sediment samples for PCBs, with 116 of these samples being collected within Green Bay to supplement the 1989-90 GBMBS data. At least 520 water samples were collected and analyzed for PCBs present in unfiltered or filtered water or present on particulate in the water column. In addition, both BBL and Exponent collected just over 300 tissue samples. This tissue data is included in the FRDB and is discussed further in the RA.

Exponent also completed a Habitat Characterization Assessment of the Lower Fox River and southern half of Green Bay. The habitat characterization data and results are discussed further in Section 4.

2.2.10 1998 RETEC RI/FS Supplemental Data

Based on review of data from the above investigations, the Project Team and WDNR collected supplemental sediment samples in selected areas of the Lower Fox River and Lake Winnebago in June 1998. These data were collected for the following:

- Evaluate upstream background concentrations in sediments for selected chemical parameters
- Collect additional information for use in the RA
- Evaluate the physical properties of the sediments for use in the FS
- Provide additional chemical information from sediment deposits containing PCBs for comparison with other data sets used in the RI

The focus of this evaluation included 12 deposits upstream of the De Pere dam that were estimated to contain over 97 percent of the PCB mass within this stretch of the river (WDNR, 1995).

The supplemental sediment sampling activities were conducted between June 1 and 8, 1998. The sample collection procedures and laboratory analytical methods are listed in the *Quality Assurance Project Plan for Supplemental Data Collection, Lower Fox River RI/FS* (RETEC, 1998b). The sediment samples were collected and analyzed for the parameters listed on Table 2-2.

The 1989-90 WDNR sediment sampling results were used as the basis for further study of a number of the deposits. Five supplemental sediment samples were collected from deposits C, E, W, X, and EE. Deposits E and EE cover such long portions of the river bottom that additional sampling in each deposit was performed to supplement existing data. Samples were collected from the sediment surface to a depth of approximately 45 cm.

Five samples were also collected from the SMUs in the De Pere to Green Bay Reach that exhibited the highest PCB concentrations in 1995. Surface sediment samples were collected and analyzed for use in the RA and to compare the Aroclor concentrations with levels of other chemicals of potential concern (COPC).

Samples were also collected from Lake Winnebago as background data. The background samples from Lake Winnebago were collected in areas where significant deposits of soft sediment were found.

These data have also been utilized in the *Time Trends Analysis* (Mountain-Whisper-Light, 2001). The time trends analysis evaluates whether PCB concentrations in sediment, fish tissue, and bird tissue samples have changed over time compared to previously collected data.

2.2.11 Lake Michigan Mass Balance Data

The Lake Michigan Mass Balance samples were collected in 1994 and 1995. Sediment, water, tissue, and air samples were collected and were analyzed for PCB congeners, volatiles, pesticides/herbicides, metals and other inorganic parameters. Although this data set contains 6,987 samples, much of the data was collected outside of the Lower Fox River and Green Bay region.

2.2.12 Fox River Fish Consumption Advisory Data

This data set is primarily tissue data with a small number of sediment samples. The tissue samples were collected by WDNR in the Fox River and Green Bay between 1971 and 1996. The 1,766 samples in this set were analyzed for PCB congeners and Aroclors, metals, chlorinated pesticides, and dioxins.

2.2.13 USGS National Water Quality Assessment Program (NAWQA) Data

The NAWQA data represent 441 sediment, water, and tissue samples collected by the USGS between 1992 and 1997. These samples were analyzed for an extensive list of chlorinated pesticides and herbicides, organophosphorus pesticides, SVOCs, and metals. Approximately 90 percent of the samples in this set were collected from waterways other than the Fox River and these samples are noted as "reference."

2.2.14 1997 WDNR Caged Fish Bioaccumulation Study Data

WDNR placed caged fish near Deposit N and SMU 56/57 prior to the start of the SRD projects. The fish and co-located sediment samples were collected and analyzed for PCB congeners. This data set consists of 25 fish tissue and sediment samples.

2.2.15 Minergy Mineralogical Data

The Minergy data are comprised of results from the analysis of 15 sediment samples for 11 different mineral oxides, sulfur, chloride, and other physical tests. None of these samples were analyzed for PCBs, dioxin, pesticide or SVOCs. Therefore, these data are of limited value in analysis of sediment impacts in the river or bay.

2.3 Ecological Sampling Studies

As indicated in Table 2-1, a number of studies that involved analysis of ecological (biological) samples for PCBs and other chemical compounds have been completed. The studies that included ecological sampling are listed below and have been divided into those studies in which only biological samples were collected and those studies that included biological sampling in addition to sediment and water sampling. The studies are listed by the total number of samples included in the FRDB (Table 2-1) and include the following:

Biological Sampling Studies

- State of Michigan Fish Consumption Advisory Data
- 1996 WDNR Fish Tissue Data
- 1998 WDNR Fish Consumption Data
- 1996-1999 USFWS NRDA Fish Tissue Data
- 1998 FRG/Exponent Data
- 1993 USFWS Tree Swallow Data
- 1994-1995 Cormorant Data
- WDNR Wildlife Tissue Data
- 1997 USFWS NRDA Waterfowl Tissue Data
- Stromberg Eagle Data Collection

Studies That Included Biological Sampling

- Lake Michigan Mass Balance Data
- 1989-90 Green Bay Mass Balance Study (GLNPO)
- Fox River Fish Consumption Advisory Data
- 1998 FRG/BBL Sediment/Tissue Data
- USGS NAWQA Data
- 1998 RETEC RI/FS Supplemental Data
- 1998/1999 Deposit N Sediment Remediation Data
- Ankley and Call (Indeterminate)
- 1996 FRG/BBL Sediment/Tissue Data
- 1997 WDNR Caged Fish Bioaccumulation Study Data

Biological sampling often included fish and bird tissue analysis. However, some studies also included analysis of bird eggshells and other biological specimens. Detailed analysis of ecological sampling and trends is presented in the *Time Trends Analysis* (Mountain-Whisper-Light, 2001) and the RA. Again, it should be noted

that the Ankley and Call data are classified as indeterminate by the DM Report (EcoChem, 2000). Use of these data are discussed further in the RA.

2.4 Section 2 Tables

Tables for Section 2 follow this page, and include:

Table 2-1 Fox River Database Studies and Data Classification
Table 2-2 Lower Fox River - Supplemental Data Collection Sampling List

Table 2-1. Fox River Database Studies and Data Classification

Data Source	Number of Samples	Matrices[1]	Analyses Conducted[2]	Number of Records	Data Quality Classification
Lake Michigan Mass Balance Data	6,987	A,S,T,W	M, P/H,PCB-C, V, W	91,621	Supporting
1989/90 Green Bay Mass Balance Study (GLNPO)	2,069	S,T,W	B, PCB-C, W	201,701	Supporting
1989/90 Fox River Mass Balance Study	1,967	S,W	PCB-A, PCB-C, W	25,457	Supporting
Fox River Fish Consumption Advisory Data	1,766	S,T	B, DXN, M, P/H, PCB-A, PCB-C, SVOA, V, W	11,620	Supporting
1998 FRG/BBL Sediment/Tissue Data	1,315	S,T,W	B, M, P/H, PCB-A, PCB-C, RAD, SVOA, W	18,824	Useable
1995 WDNR Sediment Data	488	S	M, PCB-A, W	6,433	Useable
USGS NAWQA Data	441	S,T,W	B, M, P/H, PCB, SVOA, V, W	11,879	Supporting
State of Michigan Fish Consumption Advisory Data	434	T	B, DXN, M, P/H, PCB-A, W	6,979	Useable
WDNR Wildlife Tissue Data	417	T	B, M, P/H, PCB-A	2,532	Supporting
1996-1999 USFWS NRDA Fish Tissue Data	376	T	DXN, P/H, PCB-A, PCB-C, W	16,017	Useable
1997-1998 Demonstration Project Data - SMU 56/57	295	S,W	DXN, M, P/H, PCB-A, SVOA, V, W	3,114	Useable
1994 GAS/SAIC Sediment Data	253	S	DXN, M, P/H, PCB-A, SVOA, V, W	5,654	Useable
1998 RETEC RI/FS Supplemental Data	252	S,T	B, DXN, M, P/H, PCB-A, PCB-C, SVOA, V, W	10,781	Useable
1998 FRG/Exponent Data	225	T	B, M, P/H, PCB-A, PCB-C, W	17,708	Useable
1993 USFWS Tree Swallow Data	200	T	B, DXN, P/H, V, W	5,429	Supporting
1996 WDNR Fish Tissue Data	200	T	B, PCB-A, W	1,673	Useable
1998/1999 Deposit N Sediment Remediation Data	197	T,W	PCB-C, W	10,264	Useable
1994-1995 Cormorant Data	193	T	B, DXN, P/H, PCB-C, W	6,178	Supporting
1998 WDNR Fish Consumption Data	130	T	B,M, PCB-A, W	777	Useable
1992/93 BBL Deposit A Data	117	S,W	M, P/H, PCB-A, SVOA, V, W	1,094	Useable
Lake Michigan Tributary Monitoring Data	88	W	M, P/H, PCB-C, V	5,722	Useable
1997 USFWS NRDA Waterfowl Tissue Data	70	T	B, P/H, PCB, V, W	1,680	Supporting
1994 Woodward-Clyde Deposit A Sediment Data	66	S	PCB-A, W	585	Useable
Ankley and Call	62	PW,S,T,W	DXN, M, P/H, PCB, SVOA, W	1,607	Indetereminate
1998 Deposit N Pre-Dredge	53	S	PCB-A, PCB-C, W	1,437	Useable
1998 Deposit N Post-Dredge	43	S	PCB-A, PCB-C, W	690	Useable
Stromberg Eagle Data	31	T	B, DXN, P/H, PCB-A, PCB-C, SVOA, V, W	954	Supporting
1993 Triad Assessment	27	S	B, M, P/H, PCB-A, SVOA, W	631	Supporting
1996 FRG/BBL Sediment/Tissue Data	25	S,T	B, PCB-C, W	2,771	Useable
1997 WDNR Caged Fish Bioaccumulation Study Data	25	S,T	B, PCB-C, W	1,672	Supporting
Minergy Mineralogical Data	15	S	W	219	Supporting
Lower Fox River Background Metals Assessment	14	W	M	78	Supporting
Deposit N Operational Monitoring Data	12	S	M, PCB-A, W	123	Useable
1997 Demonstration Project Data - Deposit N	10	S	M, PCB, W	83	Useable
WPDES Permit Influent Data	8	W	B, DXN, M, P/H, PCB-A, RAD, SVOA, V, W	847	Supporting

Reference - EcoChem, 2000.

1) Matrices

S = Sediment
T = Tissue
W = Water
PW = Sediment Pore Water
A = Ambiant Air

2) Analyses

PCB-A = PCB Aroclor
PCB-C = PCB Congener
PCB = Total PCB only
B = Biological
DXN = Dioxins
M = Metals
P/H = Pesticides/Herbicides
SVOA = Semi-volatiles
V = Volatiles
W = Wet Chemistry (including all Physical and Conventional data)

Table 2-2. Lower Fox River - Supplemental Data Collection Sampling List

Specific Deposit/General Area of Sampling (# of Core/Ponar Grab Sample Locations)	Sampling Parameters (both Chemical & Physical)												
	Core Samples							Surface Samples (Ponar™ Grab Samples)					
	Aroclors[1]	Atterberg limits[2]	Shear strength[2]	Specific gravity[2]	Grain size[2]	Dry density[2]	Consolidation[2]	PCB Congeners	SVOCs	Chlorinated Pesticides	Metals	TOC	Moisture content
C (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
E (6)	18	2	1	2	2	2	1	2	2	2	2	6	6
W (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
X (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
EE/22 (4)	12	2	1	2	2	2	1	2	2	2	2	4	4
EE/23 (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
EE/24 (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
EE/25 (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
EE/26 (5)	15	2	1	2	2	2	1	2	2	2	2	5	5
EE/27 (2)	0	0	0	0	0	0	0	2	0	0	0	2	2
Lake Winnebago	3	0	0	0	3	0	0	3	3	3	3	3	3
Below De Pere Dam	5	2	1	2	5	2	1	5	5	5	5	5	5
Total Number of Field Samples[3]	176	20	10	20	26	20	10	41	34	34	39	65	65

Notes:

1) Samples were collected from select intervals of each core for submittal to the laboratory for analysis.
2) Indicates that an intact core (approximately 30 cm long) was submitted for analysis of the physical parameters.
3) Total includes QA/QC samples collected as equipment rinsate or field duplicate samples.